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A Coded Wire Tag Assessment of Salmon River (Langley) Coho Salmon: 1988 Tag Application and 1989-90 Spawner Enumeration

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A CODED WIRE TAG ASSESSMENT OF SALMON RIVER (LANGLEY) COHO SALMON: 1988 TAG APPLICATION AND 1989-90 SPAWNER ENUMERATION

by

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ABSTRACT

Farwell, M.K., N.D. Schubert and L.W. Kalnin. 1991. A coded wire tag assessment of Salmon River (Langley) coho salmon: 1988 tag application and 1989-90 spawner enumeration. Can. MS Rep. Fish. Aquat. Sci. 2079: 32p.

In 1986, the Department of Fisheries and Oceans began the implemention of a plan to improve the assessment data for coho salmon (**Oncorhynchus kisutch**) through the long term evaluation of key stocks. The Salmon River (Langley) was selected for the evaluation, with known precision, of annual escapement, marine survival, harvest distribution and exploitation rate. An estimated 24,634 (corrected for long term tag loss) coho smolts were released with coded wire tags (CWT) in spring of 1988 at an average size of 93.7 mm and 8.8 g. The adult escapement was estimated in fall and winter 1989-90 using the Petersen mark-recapture method. Escapement was estimated at 8,427 coho adults of which an estimated 864 had coded wire tags and 57 (6.2%) had lost the coded wire tag. Survival to escapement was 3.5%.

Key Words: Coho salmon, Salmon River (Langley), key stream, coded wire tag, escapement, survival

RÉSUMÉ

Farwell, M.K., N.D. Schubert and L.W. Kalnin. 1991. A coded wire tag assessment of Salmon River (Langley) coho salmon: 1988 tag application and 1989-90 spawner enumeration. Can. MS Rep. Fish. Aquat. Sci. 2079: 32p.

En 1986, le ministère des Pêches et Océans a entrepris une évaluation à long terme des stocks clés pour améliorer la base de données sur le saumon coho (**Oncorhynchus kisutch**). Il a choisi de faire cette évaluation dans la rivière Salmon (Langley) et d'établir des données précises sur l'échappée annuelle, la survie, la répartition des captures et le taux d'exploitation. Au printemps de 1987, environ 24 634 (chiffre ajusté pour tenir compte des pertes à long terme de micromarques magnétisées codées) jeunes saumons mesurant en moyenne 93,7 mm, pesant en moyenne 8,8 g, et pourvus d'une micromarque magnétisée codée ont été relâchés. L'échappée des adultes a été estimée à l'automne et au printemps de 1988-89 au moyen de la technique Petersen de marquage-recapture. L'échappée a été estimée à 8 427 poissons, dont 864 avaient encore leur micromarque et 57 (6,2%) l'avaient perdue. La survie à l'échappée des cohos géniteurs de 1985 de la rivière Salmon était de 3,5%.

Mots clés: Saumon coho, rivière Salmon (Langley), cours d'eau important, micromarque magnétisée codée, échappée, survie.

INTRODUCTION

In 1986, the Department of Fisheries and Oceans began the implementation of a plan to improve the assessment data for coho salmon through the long term evaluation of key stocks. The Salmon River was selected for the evaluation, with known precision, of annual escapement, marine survival, harvest distribution and exploitation rate.

The Salmon River was designated a key stream for three reasons. First, recent escapements of Salmon River coho comprised 4% of the Fraser River total (Farwell et al. 1987). The status of this stock, therefore, is an important measure of the status of the Fraser River coho resource. Second, similar data collected from the 1976-78 brood years (Schubert 1982a; Schubert and Fleming 1989) provided a time series of comparable data. Third, simplified logistics limited project costs.

This report documents, for the 1986 brood, the 1988 coho smolt coded wire tag (CWT) application and 1989-90 coho adult escapement estimation studies. Previous reports documented the evaluation of the 1984-85 brood years (Schubert and Kalnin 1990; Kalnin and Schubert 1991). This report describes field methodologies, analytic techniques and study results, including smolt timing, age and size and adult age, length, sex, adipose fin clip (AFC) incidence and estimates of escapement and long term CWT loss. The study did not estimate the escapement of precocious males (jacks). The report concludes with a discussion of data limitations and recommendations for future studies.

STUDY AREA

The Salmon River flows northwest for 33 km, entering the Fraser River west of Fort Langley (Fig. 1). Coghlan Creek, the principal tributary, joins the mainstem 14 km upstream from the Fraser River. The system, with an average annual discharge of 1.41 m^3/s (Environment Canada 1986), drains 85 km^2 of lowland agricultural and residential land. During the Fraser River spring freshet, the Salmon River passes through a pumphouse located at the river mouth. No provisions were made for fish passage. Up to 31% of the coho smolts are killed when they pass through the pumps (Russell MS 1981).

Coho adults enter the river at ages 3_2 and 4_3 and spawn in the middle and upper reaches from November to January (Schubert 1982b; Schubert and Fleming 1989). Coho escapements averaged 3,000 and 2,400 in 1970-79 and 1980-86, respectively (Farwell et al. 1987).

METHODS

JUVENILE PROGRAM

Fish Capture

Fence traps similar to those described by Schubert (1982a) operated in Coghlan Creek (50 m above the Salmon River confluence) from April 20 to June 1, 1988 and in the Salmon River (30 m above the Coghlan Creek confluence) from April 22 to June 1, 1988.

Captured fish were enumerated at least once daily. Coho smolts were transferred to holding boxes or to the tagging site for tagging and sampling. Coho fry were not enumerated because the 6 mm fence mesh did not fully restrict their passage. The remaining catch was identified to species and released below the fence. Steelhead and cutthroat trout were recorded as smolt or presmolt. Smolts had a silver coloration and a nose-fork (NF) length greater than 11

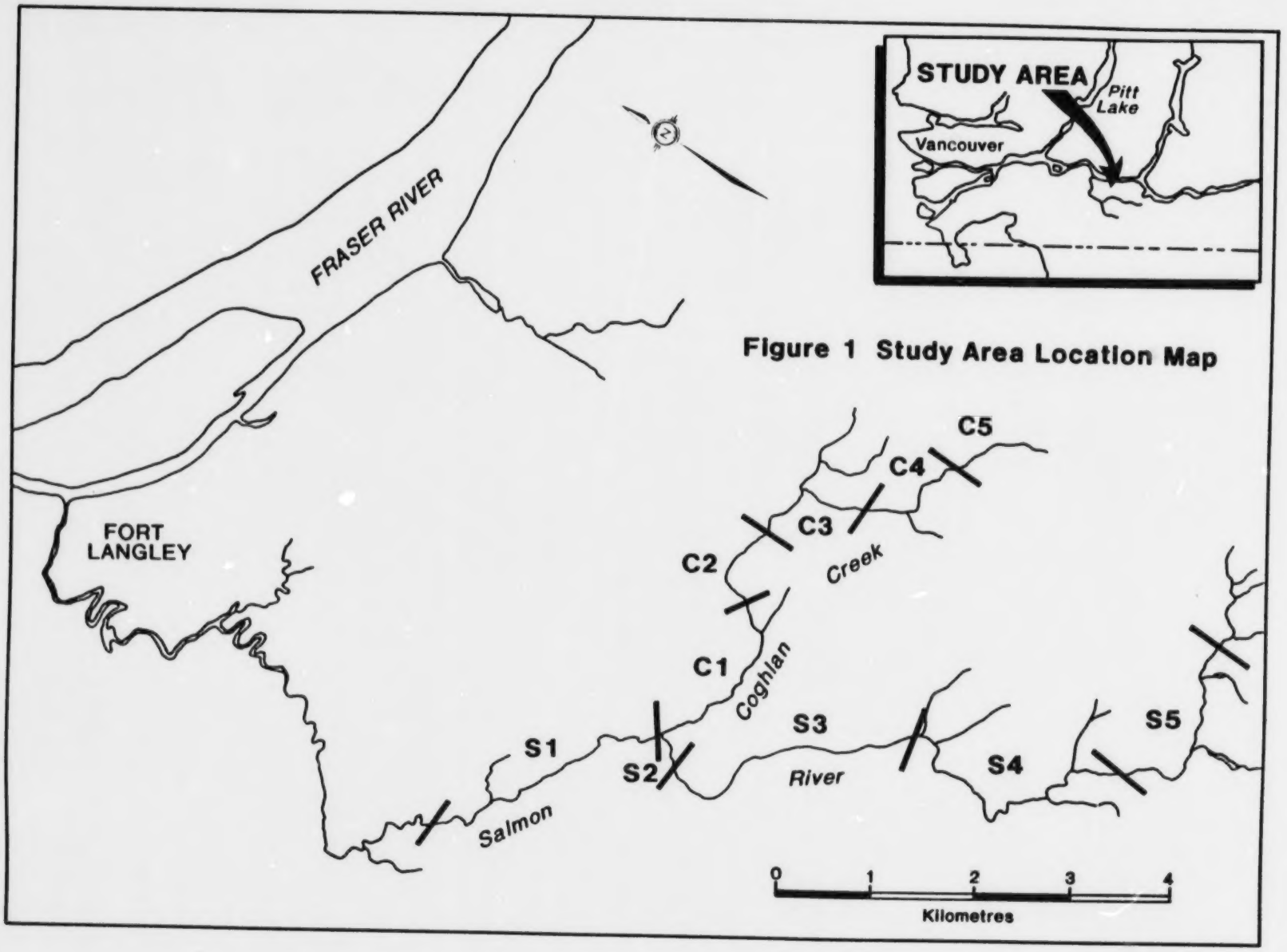

Figure 1 Study Area Location Map

cm. Presmolts had distinct parr marks and a NF length less than 11 cm.

Coded Wire Tagging

The CWT equipment and methods were described by Armstrong and Argue (1977). Coded wire tagging occurred from April 25 to June 1, 1988 at intervals of one to four days. On each day, the smolts were sorted by size (NF length greater or less than 100 mm) and separate nose molds and implant depths were used for each group. Implant depth was checked for each group by bisecting the skull of a tagged smolt along the median plane. If the CWT was not in the preferred position in the cartilaginous wedge of the skull, the implant depth was adjusted and the procedure repeated until CWT placement was correct. The nose mold was then marked to permit correct placement after nose mold changes.

The smolts were anaesthetized with Tricaine Methane Sulfonate (TMS), marked by adipose fin removal, coded wire tagged and passed through a quality control device to ensure the CWT was present. Any diseased, damaged or undersize (NF length less than 55 mm) smolts were released untagged. A representative sample of approximately 200 smolts was removed from the recovery bucket and retained for 24 hours for assessment of AFC quality, delayed mortality and CWT loss. Any coho without a CWT or with a poor AFC was retagged or reclipped. All smolts were then transported and released, or held until morning when water temperatures were more suitable for transport.

Transport

Coded wire tagged smolts were released at the Salmon River mouth to avoid pump related mortality. The smolts were transported in five gallon plastic buckets supplied with air from a twelve volt air pump. Transport required less than fifteen minutes.

Sampling

Fifty coho smolts per site were sampled twice weekly for scales, length and weight. The smolts were anaesthetized with TMS, a scale smear was removed with a scalpel from each preferred region, NF length was measured to the nearest millimeter and mean wet weight (±0.1g) was determined in aggregate on an Ohaus triple beam balance.

ADULT PROGRAM

Fish Capture

Coho adults were captured in reaches S1 to S4, C1 and C5 (Fig. 1) from October 30 to December 20, 1989. Coho were attracted from log jams and cut banks with an electroshocker using direct current. Voltage (600 volts) and frequency (15 to 30 milliseconds) were adjusted daily to ensure the fish were undamaged, but stunned sufficiently to permit capture. Stunned coho were captured in a dip net, permitted to recover in a 60 l container of water, disk tagged and released.

Disk Tag Application

Coho adults (NF length greater than 30 cm) were Petersen disk tagged in a wooden tray (10 cm x 10 cm x 100 cm) constructed with a flexible plastic bottom and a meter stick recessed in one side. The tags consisted of two 2.2 cm diameter laminated cellulose acetate disks and one 0.7 cm diameter transparent plastic buffer disk threaded through centrally punched holes onto a 7.7 cm long

nickel pin. The pin was inserted with pliers through the musculature and pterygiophore bones approximately 1.2 cm below the anterior portion of the dorsal fin insertion. The disk tags, arranged with one on each side of the fish and with a buffer disk on the pin head side, were secured by twisting the pin into a double knot. One disk per pair was numbered with a unique code. Green disk tags were used to reduce colour contrast, thereby minimizing recovery and predation biases.

Each disk tagged fish received a secondary mark to allow the assessment of disk tag loss. One or two 0.7 cm diameter holes were punched through the right operculum of males and females, respectively, using a single hole paper punch. Care was taken to avoid gill tissue damage.

Date and location (reach) of capture, disk tag number, NF length (to the nearest 0.1 cm), sex and adipose fin status were recorded for each fish released with a disk tag. Release condition was recorded as 1 (swam away vigorously), 2 (swam away sluggishly) or 3 (required ventilation). Recovered disk tagged carcasses were enumerated and sampled (described below) to assess handling mortality.

Stream Surveys

Weekly stream surveys were conducted from October 30, 1989 to January 12, 1990. Complete surveys, conducted by a two to four person crew walking in an upstream direction, required up to two days.

Live adults were counted and carcasses were recorded by date, reach, sex (confirmed by abdominal incision) and mark type (disk tag, secondary mark or AFC). Each marked carcass and every tenth unmarked carcass was sampled. Carcasses less than 30 cm NF length were recorded as jacks. All carcasses were then cut in two with a machete and returned to the river. Sample data, recorded by date and reach, included post-orbital-hypural plate (POH) length (to the nearest 0.1 cm), sex, female spawning success (0%, 50% or 100% spawned), adipose fin and carcass condition, and scale samples. For AFC coho, the head was removed posterior to the eye orbit for later CWT identification. Adipose fin condition was recorded as unclipped or as complete (flush with dorsal surface), partial (nub present) or questionable (appeared clipped but fungus or decomposition obscured area). The condition of AFC carcasses was recorded as fresh (gills red or mottled), moderately fresh (gills white, body firm), moderately rotten (body intact, flesh soft) or rotten (skin and bones), and the absence of one or both eyes was noted.

Escapement Estimation

Total Escapement: The 1989-90 escapement of Salmon River coho adults was calculated from the mark-recapture data using the Petersen formula (Chapman modification) (Ricker 1975). Total escapement was the sum of escapement by sex:

1) Estimated Salmon River system coho escapement (N_t):

$$N_t = N_m + N_f$$

where:

N_m = estimated escapement of adult males;

$$= \frac{(M_m + 1)(C_m + 1)}{(R_m + 1)}$$

N_f = estimated escapement of females, analogous to

above.

2) Estimated 95% confidence limits of N_t:

$$N_t \pm 1.96 \sqrt{V_t}$$

where:

N_t = total escapement estimate;
V_t = variance of the escapement estimate;
$= V_m + V_f$
V_m = variance of the adult male escapement estimate;

$$= \frac{(N_m^2)(C_m - R_m)}{(C_m + 1)(R_m + 2)}$$

N_m = adult male escapement estimate;
C_m = number of adult male carcasses examined for disk tags;
R_m = number of disk tagged or secondary marked adult males recovered;
V_f = variance of female escapement estimate, analogous to above.

Sex Identification Correction: The disk tag application data were corrected for sex identification error. Error occurred because the development of sexually dimorphic traits was often not advanced and internal examinations could not be made. Correction of recovery data was unnecessary because all carcasses were incised and examined internally. Sex identification error was corrected as described by Staley (1990):

3) Estimated true number of males released with disk tags and secondary marks (M_m):

$$M_m = \frac{M'_m - (M_t R_{m,f})/R_f}{1 - (R_{m,f}/R_f) - (R_{f,m}/R_m)}$$

where:

M'_m = field estimate of number of males released with disk tags and secondary marks;
M_t = total number of coho adults released with disk tags and secondary marks;
$R_{m,f}$ = number of females recovered with disk tags which were released as males;
$R_{f,m}$ = number of males recovered with disk tags which were released as females;
R_f = number of females recovered with disk tags;
R_m = number of males recovered with disk tags.

4) Estimated true number of females released with disk tags and secondary marks (M_f):

$$M_f = M_t - M_m$$

Adipose Fin Clipped Escapement: The estimated AFC escapement was the product of the AFC incidence in the carcass recovery sample, the largest of the two available samples, and the mark-recapture escapement estimate. Ninety-five percent confidence limits were calculated from the respective upper and lower confidence limits of the AFC incidence and the escapement estimate. For example, the upper 95% confidence limit of the AFC escapement estimate was the product of the upper limit of the AFC incidence and the upper limit of the total mark-recapture estimate. The mathematical relationships are reported below (Cochran 1977):

5) Estimated AFC escapement (N_a):

$$N_a = p(N_t)$$

6) Estimated 95% confidence limits for p:

$$p \pm 1.96 (se + fpc)$$

where:

p = proportion of the sample with an AFC;

se = standard error;

$$= \sqrt{(1-f)pq/(n-1)}$$

fpc = finite population correction;

$$= \frac{1}{2n}$$

n = sample size;

q = $1-p$

$$f = \frac{n}{N_t}$$

Coded Wire Tagged Escapement: Escapement by CWT code and long term CWT loss were calculated by applying the CWT composition in the carcass recovery sample to the estimated escapement of AFC adults. Apparant CWT loss was adjusted for postmortality loss resulting from carcass decomposition and predator activity, when appropriate.

RESULTS

JUVENILE PROGRAM

Fish Capture

Coho smolt catch totaled 27,091 in 1988, 17,142 in Salmon River and 9,949 in Coghlan Creek (Appendix 1). The 50% migration occurred on May 9, while the peak daily catch occurred on May 9 in the Salmon River and May 11 in Coghlan Creek. The traps were inoperable for six days in May; therefore, the true size and timing of the 1988 smolt migration were unknown.

Coded Wire Tagging

AFC and CWT releases totaled 26,380 coho smolts in 1988 (Appendix 2). When adjusted for long term CWT loss and short term (24-hour) stress-related mortality (116), the number released with CWTs and identifiable AFCs was 24,634.

Short term CWT loss averaged 1% (range 0% to 3.1%). The incidence of poor AFCs and delayed mortality averaged 0% and 0.4%, respectively. The incidence of disease, damage, or structural anomalies averaged 13.6% (3,477)(Appendix 3). The most prevalent condition was fog eye (13.4%), a reversible condition associated with capture stress. No smolts with naturally missing adipose fins were observed.

Coho Smolt Age and Size

Coho smolts emigrated from the Salmon River system entirely as yearling (age 1+) smolts. Smolt size averaged 94.5 mm and 8.9 g in the Salmon River and 92.4 mm and 8.6 g in Coghlan Creek (Appendix 4). Weighted mean smolt size was 93.7 mm and 8.8 g. Salmon River smolt size increased to a peak in mid May and decreased through the remainder of the migration. Coghlan Creek smolt size showed no consistent trend in size over the study period.

ADULT PROGRAM

Mark-Recapture

Disk Tag Application: Four hundred and ninety-five coho adults were released with disk tags and secondary marks from October 30 to December 20, 1989 (Table 1). Of that total, 96 had AFC's. Condition at

Table 1. Disk tag application, carcass examination and mark recovery by sex of Salmon River system coho adults, 1989-90.

	Disk tags applied	Carcasses examined[b]	Marked carcasses recovered[b]: Disk tag and secondary mark	Secondary mark only	Disk tag only	Total	Percent recovered
Male	264[a]	613	39	0	1	40	15.2%
Female	231[a]	710	34	0	2	36	15.6%
Adipose present	399	1,182	66	0	5	71	17.8%
Adipose absent	96	145	8	0	1	9	9.4%
Total	495	1,327[c]	74[d]	0	6[e]	80[c]	16.2%

[a] Adjusted for sex identification errors.
[b] Jacks excluded.
[c] Includes 4 disk tagged carcasses of unknown sex.
[d] Includes 1 disk tagged and secondary marked carcass of unknown sex.
[e] Includes 3 disk tagged carcasses of unknown sex.

Table 2. Disk tag application and recovery of Salmon River system coho adults, by release condition, 1989-90.

Release condition	Disk tags applied	Disk tags recovered	Percent recovered
Fish swam away without assistance	478	76	15.9%
Fish required ventilation	17	4	23.5%
Total	495	80	16.2%

release was good, except 17 (3.4%) required ventilation (Table 2). No difference ($p > 0.05$; chi-square) was noted in the proportion of this group recovered on the spawning grounds.

An estimated 7.5% of the males and 2.8% of the females were misidentified at the time of tagging (Appendix 6). When adjusted for sex identification error, an estimated 264 (53.3%) males and 231 (46.7%) females were released with disk tags and secondary marks.

Spawning Ground Recovery: One thousand, three hundred and twenty-seven adults and 47 jacks were recovered on the spawning grounds from October 30, 1989 to January 12, 1990 (Table 1; Appendix 7). Of the adults, 613 (46.3%) were male and 710 (53.7%) were female (4 were of unknown sex), 80 (6.0%) had disk tags and 145 (10.9%) had an AFC. None had lost the disk tag; however, 6 (7.5%) had no secondary mark. Eight of the AFC coho were disk tagged. The proportion of the disk tagged AFC coho which were recovered (9.4%) was significantly lower ($p < 0.05$; chi square) than for disk tagged coho with no AFC (17.8%).

Sampling Selectivity

Period: Temporal bias in the application sample was examined by comparing between periods the mark incidence in the recovery sample (Table 3). A significant difference ($p < 0.05$; chi square) was noted in females, with a higher incidence earlier in the study.

Recovery bias was examined by stratifying the application sample by period and comparing the proportions recovered (Table 4). A significant difference ($p < 0.05$) was noted, with coho tagged later in the study recovered at higher rates.

Location: Spatial bias in the application sample was examined by comparing between sections the mark incidence in the recovery sample (Table 5). Mark incidence, which ranged from 0.7% to 14.9%, was significantly different from that expected ($p < 0.05$; G-test). Mark incidence was lowest in the upper sections of Salmon River and Coghlan Creek.

Recovery bias was examined by stratifying the application sample by section and comparing the proportions recovered (Table 6). A significant difference ($p < 0.05$) was noted, with a higher recovery of coho tagged in upper Coghlan Creek.

Fish Size: Size related bias in the application sample was examined by comparing the continuous POH length frequency distributions of marked and unmarked spawning ground recoveries. No significant difference was noted in males or females ($p > 0.05$; Kolmogorov-Smirnov two sample test).

Recovery bias was examined by partitioning the application sample into recovered and nonrecovered components and comparing the continuous NF length frequency distributions of each. Although the proportion recovered increased with NF length (Table 7), the difference was not significant ($p > 0.05$).

Fish Sex: Sex related bias in the application sample was examined by comparing the sex ratio of the marked and unmarked spawning ground recoveries (Table 8). No significant difference was noted ($p > 0.05$; chi-square).

Recovery bias was examined by partitioning the application sample into recovered and nonrecovered components and comparing the sex ratio in each (Table 8). No significant difference was noted ($p > 0.05$).

Table 3. Incidence of disk tags or secondary marks in coho adults recovered on the Salmon River system spawning grounds, by period and sex, 1989-90.

Recovery period	Recovered with disk tag or secondary mark			Total recoveries[a]			Percent with disk tag or secondary mark		
	Male	Female	Total[b]	Male	Female	Total[b]	Male	Female	Total
30-Oct to 01-Dec	6	7	13	67	48	115	9.0%	14.6%	11.3%
02-Dec to 15-Dec	18	15	34	321	344	666	5.6%	4.4%	5.1%
16-Dec to 12-Jan	16	14	33	225	318	546	7.1%	4.4%	6.0%
Total	40	36	80	613	710	1,327	6.5%	5.1%	6.0%

[a] Excludes jacks.
[b] Includes 4 of unknown sex.

Table 4. Proportion of the disk tag application sample recovered on the Salmon River system spawning grounds, by application period, 1989-90.

Application period	Disk tags applied	Disk tags or secondary marks recovered	Percent recovered
30-Oct to 06-Nov	105	10	9.5%
07-Nov to 20-Nov	195	23	11.8%
21-Nov to 04-Dec	148	35	23.7%
05-Dec to 18-Dec	47	12	25.5%
Total	495	80	16.2%

Table 5. Incidence of disk tags and secondary marks, by section, in the Salmon River system spawning ground recovery sample, 1989-90.

Location	Section[a]	Carcasses examined		Carcasses recovered with disk tags or secondary marks	
		Number[b]	Percent of total	Number	Mark Incidence
Salmon River	Lower	87	6.6%	13	14.9%
	Middle	163	12.3%	23	14.1%
	Upper	455	34.3%	3	0.7%
Coghlan Creek	Lower	211	15.9%	21	10.0%
	Upper	411	31.0%	20	4.9%
Total	-	1,327	100.0%	80	6.0%

[a] Salmon River: lower - S1 and S2; middle - S3; upper - S4 and S5.
Coghlan Creek: lower - C1; upper - C2, C3, C4 and C5.
[b] Excludes jacks.

Table 6. Proportion of the disk tag application sample recovered on the Salmon River system spawning grounds, by application section, 1989-90.

Location	Section[a]	Disk tags applied		Disk tags recovered	
		Number	Percent of total	Number	Percent recovered
Salmon River	Lower	197	39.8%	15	7.6%
	Middle	85	17.2%	13	15.3%
	Upper	87	17.6%	14	16.1%
Coghlan Creek	Lower	94	19.0%	21	22.3%
	Upper	32	6.5%	17	53.1%
Total	-	495	100.0%	80	16.2%

[a] See Table 5 for section descriptions.

Table 7. Disk tag application and recovery of Salmon River system coho adults, by nose-fork length, 1989-90.

Nose-fork length (cm)	Disk tags applied	Carcasses recovered with disk tags	Percent recovered
30-39	11	0	0.0%
40-49	78	3	3.9%
50-59	319	54	16.9%
60-69	85	23	27.1%
Total	495[a]	80	16.2%

[a] Includes 2 coho adults not measured at release.

Table 8. Sex composition of Salmon River system coho adults in the disk tag application and spawning ground recovery samples, 1989-90.

		Application sample[a]			Spawning ground recovery sample[b]		
Sex		Recovered	Not Recovered	Total	Disk tag and secondary mark	Unmarked	Total
Male	N	40	224	264	40	573	613
	%	52.6	53.5	53.3	52.6	46.0	46.3
Female	N	36	195	231	36	674	710
	%	47.4	46.5	46.7	47.4	54.0	53.7
Total		76	419	495	80[c]	1,247	1,327[c]

[a] Corrected for sex identification error.
[b] Excludes jacks.
[c] Includes 4 of unknown sex.

Furthermore, no significant difference was noted in the proportion of males (15.2%) and females (15.6%) released with disk tags and recovered on the spawning grounds (Table 1).

Spawning Success: Spawning success, estimated from the internal examination of female spawning ground recoveries, was estimated at 92.1% (Appendix 8). Spawning success of marked (81.3%) and unmarked (95.7%) females was significantly different ($p < 0.05$; difference in proportions test).

Estimation of Spawner Population

Total Escapement: The 1989-90 escapement of Salmon River coho adults, calculated from mark-recapture data, was 8,427 (Table 9). Upper and lower 95% confidence limits were 10,230 and 6,624, respectively. The escapement of female and male coho adults was 4,458 and 3,969, respectively.

Adipose Fin Clipped Adults: Based on the coho adult AFC incidence in the spawning ground sample (10.9%; Table 1), the 1989-90 escapement of AFC adults was 921, with upper and lower 95% confidence limits of 1,283 and 617, respectively (Table 9). Of that total, an estimated 864 returned with a CWT (02 49 38) and 57 (6.2%) had lost the CWT (Appendix 9). CWT loss was not influenced by carcass condition or predators ($p > 0.05$; chi-square) (Appendix 10). Survival from smolt release to adult escapement was 3.5%.

Age, Length and Sex

The age and length of 247 coho salmon recovered on the spawning grounds is summarized by sex in Appendix 11. All sampled females were age 3_2. The males were 94.2% age 3_2 and 5.8% age 2_2.

Mean NF length of male adults and females in the application sample was 52.2 cm and 55.6 cm, respectively (Appendix 11). No significant difference ($p > 0.05$; single class ANOVA) was noted between those with and without an AFC. Females were significantly longer than males ($p < 0.05$; single class ANOVA). Mean POH length of male adults and females in the recovery sample was 43.5 cm and 46.2 cm, respectively (Appendix 11). No significant difference ($p > 0.05$; single class ANOVA) was noted between those with and without an AFC. Females were significantly longer than males ($p < 0.05$; single class ANOVA).

Females comprised 46.7% of the application sample, 53.7% of the recovery sample (Table 8) and 52.9% of the Petersen population estimate.

DISCUSSION

ADULT CAPTURE TECHNIQUE

A basic assumption underlying Petersen mark-recapture studies is that capture and tagging must not influence the subsequent catchability of the fish. Previous studies in the Salmon River (Schubert and Kalnin 1990; Kalnin and Schubert 1991) identified a potential concern with stress resulting from the use of electric current. Since the inception of this study in 1987, there has been a consistent significant difference in the spawning success of marked and unmarked females. This suggests that capture stress influenced subsequent survival; however, we were unable to determine if a behavioral change associated with reduced spawning success would also influence catchability. We reiterate, therefore, that this factor should be evaluated in future studies.

Table 9. Escapement estimates, by sex and AFC status, for Salmon River system coho adults, 1989-90.

	Escapement estimates	95% confidence limit	
		Lower	Upper
Male	3,969	2,809	5,129
Female	4,458	3,078	5,838
Total	8,427	6,624	10,230
AFC[a] Adult	921	617	1,283

[a] Adipose fin clipped.

Table 10. Smolt release, adult escapement and survival to adult escapement of coded wire tagged 1986 brood Salmon River system coho salmon.

CWT Code	Brood year	Number released[a]	Spawning ground recoveries		Estimated AFC escapement	Percent survival to escapement
			Number	%		
02 49 38	1986	24,634	136	93.7%	864	3.5%
No pin	-	-	9	6.2%	57	-

[a] Adjusted for long term CWT loss.

Table 11. Results of statistical tests for bias in the 1989-90 Salmon River escapement estimation study.

Test	Application Sample	Recovery Sample
Period	Bias towards earlier period	Bias towards later period
Location	Bias in upper Salmon River	Bias in upper Coghlan Creek
Fish size	No bias	No bias
Fish sex	No bias	No bias

SAMPLING SELECTIVITY

A second assumption underlying Petersen mark-recapture studies is that the population is sampled in a random or representative manner (Ricker 1975). In studies when nonrepresentative sampling occurs, accurate results may still be achieved if one sample is representative (Robson 1969). In the present study, it was not possible to test for representativeness because the true population parameters were not known. Instead, we examined the samples for four biases, temporal, spatial, fish size and fish sex, as indicators of weaknesses in the study design. Significant biases were identified in both the tag application and recovery samples (Table 11). The application sample was biased with respect to period and location and unbiased with respect to fish size and sex. The recovery sample was biased with respect to period and location and unbiased with respect to fish size and sex.

The most serious bias was the non-random distribution of tags among the spawner population. Temporal bias was noted in both the application and recovery samples; however, because the direction of the biases was dissimilar, estimation error was probably minor. To investigate this assumption, we stratified the data by period and estimated the escapement using Schaefer's modification of the Petersen method for use with stratified populations (Ricker 1975). The resulting estimate was within 6% of the Petersen estimate and well within it's 95% confidence limits. We concluded, therefore, that the assumption was valid.

Spatial bias was also noted in both the application and recovery samples, the former with a positive bias in upper Coghlan Creek and the latter with a negative bias in upper Salmon River. When the data were stratified spatially, the resulting escapement estimate was 14.8% below the Petersen estimate but within the lower 95% confidence limit. This suggests that spatial bias may have introduced an positive bias in the Petersen estimate; however, because the Schaefer estimate was subject to the same biases (Ricker 1975), the magnitude of the potential estimation error could not be determined from the present data. Because the Schaefer estimate was within the 95% confidence estimate of the Petersen estimate we concluded that, although suspect, the latter provided the best estimate of the 1989-90 escapement. We note, however, that spatial and temporal distribution patterns should be assessed before undertaking future sampling studies.

SUMMARY

1. The Salmon River (Langley) coho stock is one of a group of British Columbia stocks being monitored to evaluate responses to management actions by measuring, with known precision, annual escapement, marine survival, harvest distribution and exploitation rate.

2. Coded wire tags (CWT) and adipose fin clips (AFC) were applied to emigrant smolts from April 20 to June 1, 1988. Smolts were captured at fence traps in the Salmon River and Coghlan Creek, the principal tributary. Tagged smolts were transported and released downstream of a pumphouse at the river mouth.

3. A total of 24,634 coho smolts were release with CWTs and AFCs. Size averaged 93.7 mm NF length and 8.8 g wet weight.

4. Adult spawners were enumerated

by a mark-recapture study from October 30, 1989 to January 12, 1990. Coho adults were captured using an electroshocker and marked with Petersen disk tags and opercular punches. The escapement was censused by the recovery of carcasses following spawning.

5. The 1989-90 coho adult escapement was estimated from a disk tag application sample of 495, a recovery sample of 1,327, and a recovery of 80 carcasses with disk tags. The estimated escapement was 8,427 coho adults, of which 4,458 were female, 3,969 were male, and 921 had adipose fin clips.

6. The estimated return to the spawning grounds of code 02 49 38 was 864. Survival from smolt release to spawning ground recovery was 3.5% while CWT loss was 6.2%.

7. The age composition of coho adults, measured from the recovery sample, was entirely age 3_2. Adult POH length averaged 43.5 cm for males and 46.2 cm for females.

8. Biases were identified in both the application and recovery samples. The spatial bias may have been sufficiently severe to make the accuracy of the escapement estimate suspect.

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APPENDICES

Appendix 1a. Daily fence trap catches in the Salmon River, 1988.

Date	Water temp. (C) a	Water level (m) a	Coho smolt	Cutthroat		Rainbow		Lamprey	Sculpin	Stickle-back	Cray-fish	Sucker
				Smolt	Parr	Smolt	Parr					
22-Apr	-	-	0	0	0	0	0	0	0	0	0	0
23-Apr	-	-	0	0	0	0	0	0	0	0	0	0
24-Apr	10.0	-	182	20	0	2	0	3	0	0	0	0
25-Apr	-	-	268	37	25	4	0	2	0	0	0	0
26-Apr	10.0	-	250	50	10	8	0	6	0	0	0	0
27-Apr	9.5	-	538	37	15	7	0	1	0	0	0	0
28-Apr	11.0	-	864	70	15	7	0	1	0	0	0	0
29-Apr	11.0	0.16	976	138	32	17	0	4	0	0	0	0
30-Apr	9.0	0.24	1,004	324	80	28	0	0	0	1	0	0
01-May	9.0	-	14	1	0	0	0	0	0	0	0	0
02-May	9.0	0.23	0	15	8	2	0	3	0	1	0	0
03-May	9.0	0.31	114	92	27	16	0	0	0	0	0	0
04-May	11.0	0.24	20	10	2	0	0	0	0	1	0	0
05-May	10.0	0.20	326	25	13	3	0	0	0	0	0	0
06-May	11.0	0.19	207	3	0	0	0	2	0	2	0	0
07-May	11.0	0.18	751	13	24	10	0	0	0	0	0	0
08-May	-	-	207	0	3	1	0	1	0	2	0	0
09-May	12.0	0.16	4,231	202	25	21	0	0	0	0	0	0
10-May	12.0	0.14	544	70	30	16	0	1	0	0	1	0
11-May	13.0	0.14	1,595	38	20	5	0	2	0	0	0	0
12-May	14.0	0.14	1,369	36	12	6	0	6	0	0	1	0
13-May	12.0	0.22	587	34	32	20	0	2	0	0	0	0
14-May	12.0	0.24	1,814	130	34	4	0	0	0	0	0	0
15-May	15.0	0.20	596	208	30	14	0	0	0	0	0	0
16-May b	13.0	0.24	-	-	-	-	-	-	-	-	-	-
17-May b	12.0	0.49	-	-	-	-	-	-	-	-	-	-
18-May b	11.0	-	-	-	-	-	-	-	-	-	-	-
19-May b	-	-	-	-	-	-	-	-	-	-	-	-
20-May b	-	-	-	-	-	-	-	-	-	-	-	-
21-May b	12.0	-	-	-	-	-	-	-	-	-	-	-
22-May	14.0	0.24	2	0	1	0	0	0	0	0	0	0
23-May	11.0	0.26	161	49	9	3	0	2	0	0	0	0
24-May	11.0	0.25	147	16	2	0	0	0	1	0	0	0
25-May	12.0	0.24	37	2	1	0	0	4	0	1	0	0
26-May	12.0	0.23	65	0	0	0	0	0	0	0	0	0
27-May	12.5	0.23	53	16	1	0	0	1	1	0	0	0
28-May	12.5	0.24	0	0	0	0	0	2	0	0	0	0
29-May	10.5	0.26	47	41	0	0	0	2	0	0	0	0
30-May	11.0	0.24	136	29	7	3	0	0	0	1	0	0
31-May	12.0	0.24	37	16	2	0	0	4	0	0	0	0
01-Jun	11.0	0.25	0	0	0	0	0	0	0	0	0	0
Total	-	-	17,142	1,722	460	197	0	49	2	9	2	0

a. Recorded at approximately 0830 hrs.
b. Trap out due to high water.

Appendix 1b. Daily fence trap catches in Coghlan Creek, 1988.

Date	Water temp. (C) a	Water level (m) a	Coho smolt	Cutthroat Smolt	Cutthroat Parr	Rainbow Smolt	Rainbow Parr	Lamprey	Sculpin	Stickle-back	Cray-fish	Sucker
20-Apr	-	0.30	10	1	0	0	0	0	0	0	0	0
21-Apr	-	-	25	1	1	1	0	0	0	0	0	0
22-Apr	10.5	-	19	1	6	1	0	7	0	0	3	0
23-Apr	-	-	137	0	0	0	0	0	0	0	0	0
24-Apr	-	-	86	0	0	0	0	0	0	0	0	0
25-Apr	-	-	167	15	4	2	0	0	0	0	0	0
26-Apr	-	-	68	10	4	1	0	3	0	0	0	0
27-Apr	10.0	-	327	25	3	5	0	2	0	0	0	0
28-Apr	11.0	-	356	19	9	9	0	2	0	0	0	0
29-Apr	10.0	0.33	590	95	23	3	0	0	0	0	1	0
30-Apr	9.0	0.43	152	62	17	4	0	2	0	0	0	0
01-May	8.0	-	87	19	5	1	0	0	0	0	0	0
02-May	9.0	0.37	71	8	2	0	0	0	0	0	0	0
03-May	9.0	0.47	502	63	28	7	0	0	0	0	1	0
04-May	10.0	0.37	437	76	11	5	0	1	0	0	0	0
05-May	9.0	0.33	155	4	1	0	0	0	1	0	0	0
06-May	10.0	0.31	797	141	30	8	0	1	0	0	0	0
07-May	10.0	0.31	569	117	10	3	0	0	0	1	0	0
08-May	-	-	171	26	12	1	0	1	0	0	0	0
09-May	11.0	0.29	865	304	84	12	0	1	0	0	0	0
10-May	11.0	0.27	792	128	14	2	0	1	0	0	2	0
11-May	12.0	0.28	884	149	25	5	0	0	0	0	0	0
12-May	13.0	0.27	701	202	19	2	0	0	0	0	0	0
13-May	12.0	0.41	440	211	32	10	0	1	0	0	0	0
14-May	12.0	0.40	485	83	18	6	0	0	0	0	1	0
15-May	14.0	0.33	340	139	8	2	0	1	0	0	0	0
16-May b	12.0	0.43	-	-	-	-	-	-	-	-	-	-
17-May b	12.0	0.45	-	-	-	-	-	-	-	-	-	-
18-May b	11.0	0.39	-	-	-	-	-	-	-	-	-	-
19-May b	-	-	-	-	-	-	-	-	-	-	-	-
20-May b	-	-	-	-	-	-	-	-	-	-	-	-
21-May	11.0	0.30	10	14	0	0	0	0	0	0	0	0
22-May	13.0	0.27	126	162	14	7	0	3	0	0	2	0
23-May	10.5	0.31	32	112	7	0	0	1	0	0	1	0
24-May	10.0	0.29	141	77	8	1	0	1	0	0	3	0
25-May	11.0	0.28	64	70	3	0	0	2	0	1	0	0
26-May	11.0	0.28	43	63	3	0	0	0	0	0	0	0
27-May	12.5	0.28	64	36	3	0	0	1	1	0	0	0
28-May	12.0	0.40	78	72	7	0	0	0	0	0	0	1
29-May	10.0	0.32	109	71	7	2	0	1	1	0	0	0
30-May	10.0	0.30	23	58	4	0	0	0	0	0	0	0
31-May	11.0	0.29	15	29	0	0	0	0	0	0	0	0
01-Jun	11.0	0.32	11	28	2	0	0	0	0	0	0	0
Total	-	-	9,949	2,691	424	100	0	32	3	2	14	1

a. Recorded at approximately 0830 hrs.

b. Trap out due to high water.

Appendix 2a. Salmon River coded wire tagging results (code 02 49 38), 1988.

Tagging date	Maximum holding time (days)	Pre-tagging mort-ality	Total number marked	24 hour CWT rejection		Post tagging mortality		Total released with CWTs c
				N a	(%)	Immediate	24-hour b	
25-Apr	2	1	442	169	1.8	0	0	415
26-Apr	0	2	248	248	1.2	0	13	220
27-Apr	0	0	538	239	1.7	1	0	504
28-Apr	0	0	864	170	1.8	1	0	809
29-Apr	0	0	974	201	0.0	2	0	912
30-Apr	0	13	991	173	0.6	9	8	914
02-May	2	0	14	159	1.3	0	0	13
03-May	0	0	114	114	0.9	0	2	105
04-May	0	0	20	20	0.0	0	0	19
06-May	0	2	531	210	1.0	6	0	492
09-May	2	0	3,356	263	0.4	21	0	3,128
10-May	0	1	2,037	234	2.6	11	1	1,899
11-May	0	1	1,476	253	0.4	2	0	1,383
12-May	0	0	1,369	192	3.1	1	0	1,283
16-May	3	0	0	0	0.0	0	0	0
17-May	0	0	2,493	209	1.0	5	0	2,334
18-May	0	0	468	176	0.6	3	1	435
24-May	3	0	321	163	0.0	0	0	301
25-May	0	0	37	37	0.0	0	0	35
26-May	0	0	76	76	0.0	0	0	71
27-May	0	0	49	49	2.0	0	0	46
30-May	2	0	199	199	0.0	0	0	187
01-Jun	1	0	37	37	0.0	0	0	35
Total	(Mean)	20	16,654	3,591	1.12	62	25	15,539

a. Sample size held to assess tag loss.
b. Based on mortality rate observed in QCD subsample expanded to entire tag lot.
c. Adjusted for long term CWT loss (see text).

Appendix 2b. Coghlan Creek coded wire tagging results (code 02 49 38), 1988.

Tagging date	Maximum holding time (days)	Pre-tagging mort-ality	Total number marked	24 hour CWT rejection		Post tagging mortality		Total released with CWTs c
				N a	(%)	Immediate	24-hour b	
25-Apr	5	1	431	150	1.3	0	0	404
26-Apr	0	1	77	77	1.3	0	0	72
27-Apr	0	0	326	190	1.6	1	1	304
28-Apr	0	0	351	176	1.7	0	0	329
29-Apr	0	0	588	239	0.0	0	0	552
30-Apr	0	1	60	60	0.0	1	0	55
02-May	2	2	145	145	0.7	0	1	135
03-May	0	0	509	198	1.5	0	2	476
04-May	0	0	431	223	0.4	5	1	399
05-May	0	0	152	152	0.7	0	0	143
06-May	0	5	768	189	0.5	8	0	713
09-May	2	0	1,605	270	0.4	3	0	1,503
10-May	0	2	792	217	2.3	4	0	739
11-May	0	0	884	271	0.4	1	1	827
12-May	0	0	685	241	2.9	0	0	642
16-May	3	0	916	273	0.0	0	0	859
18-May	0	0	300	213	0.5	0	0	281
24-May	5	0	309	184	0.0	0	0	290
25-May	0	0	64	64	1.6	0	0	60
26-May	0	0	43	43	0.0	0	0	40
27-May	0	0	64	64	0.0	0	0	60
30-May	2	0	200	200	0.0	0	0	188
01-Jun	2	0	26	26	0.0	0	0	24
Total	(Mean)	12	9,726	3,865	0.85	23	6	9,095

a. Sample size held to assess tag loss.
b. Based on mortality rate observed in QCD subsample expanded to entire tag lot.
c. Adjusted for long term CWT loss (see text).

Appendix 3. Incidence of anomalies encountered while coded wire tagging wild Salmon River system coho salmon smolts, 1988.

Location	Number Inspected	Fog eye	Neascus	Fin rot	General damage
Salmon River	16,109	2,158	16	13	6
	%	13.4%	0.1%	0.1%	<0.1
Coghlan Creek	9,462	1,259	9	14	2
	%	13.3%	0.1%	0.1%	<0.1
Total	25,571	3,417	25	27	8
	% total	13.4%	0.1%	0.1%	<0.1

Appendix 4. Mean length and weight of coho salmon smolts in the Salmon River system, 1988.

Location	Sample date	Sample size	Nose-Fork length (mm) Mean	Nose-Fork length (mm) Standard deviation	Mean wet weight (g)
Salmon River	26-Apr	50	87.9	9.7	7.3
	29-Apr	50	88.9	7.9	7.4
	06-May	50	96.3	9.9	9.5
	10-May	50	97.1	8.6	9.6
	24-May	50	94.5	7.2	8.9
	27-May	50	93.7	7.1	8.7
	31-May	37	92.6	7.3	7.9
	Total	337	94.5 a	-	8.9 a
Coghlan Creek	26-Apr	50	95.4	14.3	9.7
	29-Apr	50	88.5	9.6	8.4
	04-May	50	92.6	10.1	8.4
	06-May	50	94.6	8.9	8.9
	10-May	50	95.3	9.0	9.3
	24-May	50	90.9	7.3	8.1
	27-May	50	91.1	5.7	8.1
	31-May	14	89.0	3.5	8.1
	Total	364	92.4 a	-	8.6 a
Total	-	701	93.7 a	-	8.8 a

a. Weighted by proportion of smolt migration in time periods.

Appendix 5a. Coho adult disk tag application results in the Salmon River, 1989-90. a

		Adipose present			Adipose absent			Total		
Date	Reach b	Male	Female	Total	Male	Female	Total	Male	Female	Total
30-Oct	S1	7	6	13	2	4	6	9	10	19
01-Nov	S1	16	9	25	4	3	7	20	12	32
	S2	1	0	1	0	0	0	1	0	1
03-Nov	S1	3	1	4	1	0	1	4	1	5
	S4	4	0	4	2	2	4	6	2	8
06-Nov	S1	11	16	27	2	3	5	13	19	32
	S4	5	1	6	1	1	2	6	2	8
08-Nov	S1	5	6	11	1	1	2	6	7	13
	S2	1	1	2	0	0	0	1	1	2
	S4	5	4	9	6	6	12	11	10	21
15-Nov	S1	7	16	23	0	3	3	7	19	26
	S2	0	2	2	0	0	0	0	2	2
	S4	9	8	17	8	2	10	17	10	27
17-Nov	S1	11	20	31	1	0	1	12	20	32
	S3	16	15	31	4	2	6	20	17	37
20-Nov	S3	3	3	6	0	1	1	3	4	7
22-Nov	S1	8	10	18	0	1	1	8	11	19
	S3	5	4	9	0	1	1	5	5	10
	S4	8	2	10	1	1	2	9	3	12
24-Nov	S1	0	0	0	0	0	0	0	0	0
	S3	4	4	8	1	2	3	5	6	11
	S4	2	2	4	1	0	1	3	2	5
27-Nov	S1	0	5	5	0	0	0	0	5	5
	S2	1	0	1	0	0	0	1	0	1
	S3	3	1	4	1	1	2	4	2	6
	S4	0	1	1	0	0	0	0	1	1
29-Nov	S1	1	2	3	0	0	0	1	2	3
	S3	6	1	7	0	0	0	6	1	7
	S4	0	2	2	1	1	2	1	3	4
11-Dec	S2	0	2	2	0	0	0	0	2	2
	S3	2	5	7	0	0	0	2	5	7
	S4	0	1	1	0	0	0	0	1	1
20-Dec	S1	0	2	2	0	0	0	0	2	2
	S2	1	0	1	0	0	0	1	0	1
Total	S1	69	93	162	11	15	26	80	108	188
	S2	4	5	9	0	0	0	4	5	9
	S3	39	33	72	6	7	13	45	40	85
	S4	33	21	54	20	13	33	53	34	87
	Total	145	152	297	37	35	72	182	187	369

a. Not corrected for sex identification error.

b. Salmon River reaches:
S1 - below Coghlan Creek.
S2 - Coghlan Creek to 64 Ave.
S3 - 64 Ave. to 56 Ave.
S4 - 56 Ave. to 248 St.
S5 - 248 St. to 256 St.

Appendix 5b. Coho adult disk tag application results in Coghlan Creek, 1989-90. a

		Adipose present			Adipose absent			Total		
Date	Reach b	Male	Female	Total	Male	Female	Total	Male	Female	Total
15-Nov	C1	9	8	17	4	1	5	13	9	22
17-Nov	C1	3	2	5	1	0	1	4	2	6
22-Nov	C1	5	4	9	1	0	1	6	4	10
24-Nov	C1	6	5	11	0	1	1	6	6	12
	C5	15	5	20	5	7	12	20	12	32
27-Nov	C1	2	2	4	0	0	0	2	2	4
29-Nov	C1	2	3	5	1	0	1	3	3	6
11-Dec	C1	13	16	29	2	1	3	15	17	32
20-Dec	C1	0	2	2	0	0	0	0	2	2
Total	C1	40	42	82	9	3	12	49	45	94
	C5	15	5	20	5	7	12	20	12	32
	Total	55	47	102	14	10	24	69	57	126

a. Not corrected for sex identification error.

b. Coghlan Creek reaches:
C1 - Salmon River to Hwy. 1.
C2 - Hwy. 1 to 248 St.
C3 - 248 St. to 64 Ave.
C4 - 64 Ave. to 256 St.
C5 - Above 256 St.

Appendix 6. Disk tag recoveries in the Salmon River system, by application and recovery date and location, 1989-90.

Application sample					Recovery sample					
Date	Reach c	NF length (cm)	Sex	Adipose fin	Date	Reach	POH length (cm)	Sex		Time out (days)
01-Nov	S1	61.0	F	P	01-Dec	S3	47.8	F		30
01-Nov	S1	55.5	F	P	11-Dec	C1	43.4	F		40
06-Nov	S1	47.9	F	P	17-Nov	S1	35.8	M	a	11
06-Nov	S1	54.5	F	P	11-Dec	S1	42.2	F		35
06-Nov	S1	68.5	M	A	07-Dec	C4	54.0	M		31
06-Nov	S1	52.8	M	P	20-Dec	S1	-	M		44
06-Nov	S1	58.8	F	P	01-Dec	S1	45.7	F		25
06-Nov	S1	54.8	F	P	15-Dec	S1	45.4	F		39
06-Nov	S4	57.4	M	P	01-Dec	S3	45.4	M		25
06-Nov	S4	57.8	M	P	01-Dec	S3	42.8	M		25
08-Nov	S2	62.2	F	P	11-Dec	C1	49.8	F		33
15-Nov	C1	53.8	F	P	20-Dec	C1	42.9	F		35
15-Nov	C1	55.5	F	P	12-Jan	S1	-	F		58
15-Nov	C1	57.4	M	P	11-Dec	C1	45.3	M		26
15-Nov	C1	56.1	M	P	07-Dec	C1	-	M		22
15-Nov	S1	54.4	F	P	20-Dec	S1	-	F	b	35
15-Nov	S4	58.3	M	A	01-Dec	S3	44.4	M		16
15-Nov	S4	57.8	F	P	01-Dec	S3	46.8	F		16
15-Nov	S4	55.9	M	P	15-Dec	S3	44.6	M		30
15-Nov	S4	56.7	F	P	01-Dec	S3	48.2	F		16
15-Nov	S4	66.5	M	P	01-Dec	S3	55.4	M		16
17-Nov	C1	62.1	F	P	07-Dec	C5	49.5	F		20
17-Nov	S1	54.0	F	P	13-Dec	C3	45.2	F		26
17-Nov	S1	61.9	F	P	01-Dec	S1	52.4	F		14
17-Nov	S3	56.1	F	P	01-Dec	S3	45.5	F		14
17-Nov	S3	63.1	F	P	13-Dec	S4	49.6	F		26
17-Nov	S3	56.7	F	P	18-Dec	S4	45.6	F		31
17-Nov	S3	59.1	M	P	29-Dec	S3	-	-	b	42
17-Nov	S3	58.7	M	P	15-Dec	S3	47.6	M		28
17-Nov	S3	61.2	F	P	15-Dec	S3	43.8	F		28
17-Nov	S3	46.2	F	P	29-Dec	S3	-	-		42
17-Nov	S3	63.5	M	P	29-Dec	S3	-	M		42
20-Nov	S3	54.2	M	P	15-Dec	C2	43.3	M		25
22-Nov	C1	58.9	F	P	20-Dec	C1	46.8	F		28
22-Nov	S1	55.1	M	P	11-Dec	C1	43.5	M		19
22-Nov	S3	58.7	F	P	01-Dec	S3	49.2	F		9
22-Nov	S4	53.2	M	P	01-Dec	S3	39.2	M		9
22-Nov	S4	57.5	M	P	29-Dec	S1	44.8	M		37
22-Nov	S4	51.7	M	P	20-Dec	S3	40.3	M		28
22-Nov	S4	62.4	M	P	15-Dec	S3	48.1	M		23
22-Nov	S4	50.5	M	P	20-Dec	S3	40.4	M		28
24-Nov	C1	63.5	M	P	08-Jan	C1	-	-	b	45

Appendix 6. Disk tag recoveries in the Salmon River system, by application and recovery date and location, 1989-90.

Application sample					Recovery sample					
Date	Reach c	NF length (cm)	Sex	Adipose fin	Date	Reach	POH length (cm)	Sex		Time out (days)
24-Nov	C5	60.9	F	A	07-Dec	C4	47.7	F		13
24-Nov	C5	56.0	F	A	07-Dec	C4	45.5	F		13
24-Nov	C5	60.1	F	A	07-Dec	C4	48.4	F	b	13
24-Nov	C5	60.7	M	P	07-Dec	C5	46.2	M		13
24-Nov	C5	66.8	M	P	13-Dec	C3	51.3	M		19
24-Nov	C5	54.5	M	P	18-Dec	C3	43.1	M		24
24-Nov	C5	55.7	M	P	07-Dec	C1	43.3	M		13
24-Nov	C5	55.2	M	P	07-Dec	C4	-	M		13
24-Nov	C5	59.2	M	P	07-Dec	C4	45.3	M		13
24-Nov	C5	64.7	F	P	07-Dec	C4	51.5	F		13
24-Nov	C5	61.0	F	A	07-Dec	C4	48.5	F		13
24-Nov	C5	54.6	F	A	27-Dec	C4	-	M	a	33
24-Nov	C5	50.0	M	A	07-Dec	C4	40.4	M		13
24-Nov	C5	66.3	M	P	07-Dec	C4	53.3	F	a	13
24-Nov	C5	54.1	F	P	27-Dec	C4	-	F		33
24-Nov	C5	51.8	M	P	18-Dec	C5	43.3	M		24
24-Nov	C5	62.0	M	P	07-Dec	C4	49.5	M		13
24-Nov	S3	54.0	M	P	29-Dec	S3	42.1	M		35
24-Nov	S3	57.4	F	P	27-Dec	S4	45.1	F		33
24-Nov	S4	56.4	F	P	15-Dec	S3	-	-	b	21
27-Nov	C1	59.0	F	P	07-Dec	C1	45.5	F		10
27-Nov	C1	48.4	M	P	07-Dec	C1	36.7	M		10
29-Nov	C1	53.9	F	P	20-Dec	C1	43.8	F		21
29-Nov	C1	63.1	M	P	11-Dec	C1	51.2	M		12
29-Nov	S3	57.9	M	P	29-Dec	S3	45.5	M		30
29-Nov	S4	51.7	F	A	15-Dec	S3	40.6	M	a	16
11-Dec	C1	51.5	F	P	29-Dec	C1	39.6	F		18
11-Dec	C1	58.7	F	P	08-Jan	C1	-	F		28
11-Dec	C1	54.2	M	P	29-Dec	C1	43.1	M		18
11-Dec	C1	50.2	M	P	20-Dec	C1	39.4	M		9
11-Dec	C1	60.2	M	P	12-Jan	S1	47.5	M	b	32
11-Dec	C1	56.6	M	P	29-Dec	C1	43.6	M		18
11-Dec	C1	53.8	F	P	29-Dec	C1	44.6	F		18
11-Dec	C1	53.9	F	P	12-Jan	S1	41.4	F		32
11-Dec	C1	52.5	M	P	08-Jan	C1	43.2	M		28
20-Dec	C1	57.1	F	P	29-Dec	C1	46.4	F		9
20-Dec	S1	54.7	F	P	12-Jan	S1	43.6	F		23
20-Dec	S2	64.0	M	P	29-Dec	S1	49.5	M		9

Appendix 6. Disk tag recoveries in the Salmon River system, by application and recovery date and location, 1989-90.

Application sample					Recovery sample				
Date	Reach c	NF length (cm)	Sex	Adipose fin	Date	Reach	POH length (cm)	Sex	Time out (days)

Summary:

Females initially identified as males:	1	2.8%	Mean days out =	23.6
Males initially identified as females:	3	7.5%	Maximum days out =	58.0
			Minimum days out =	9.0

POH and NF regressions:

- Adult males: POH length = 0.8 NF - 1.02
  NF length = 1.14 POH + 6.07
- Adult females: POH length = 0.76 NF + 2.10
  NF length = 1.00 POH + 11.76

a. Incorrect sex identification during disk tag application

b. No secondary mark on recovery

c. Salmon River: S1 - below Coghlan Cr.
S2 - Coghlan Cr. to 64 Ave.
S3 - 64 Ave. to 56 Ave.
S4 - 56 Ave. to 248 St.
S5 - 248 St. to 256 St.

Coghlan Creek: C1 - Salmon R. to Hwy 1.
C2 - Hwy 1 to 248 St.
C3 - 248 St. to 64 Ave.
C4 - 64 Ave. to 256 St.
C5 - Above 256 St.

Appendix 7a. Summary of live observations and dead counts of coho salmon in the Salmon River, 1989-90.

			Dead count									
			Adipose fin present			Adipose fin absent						
Date	Reach	Live count	Male	Female	Jack	Male	Female	Jack	Adult total	Disk tag and secondary mark	Second-ary mark only	Disk tag only
30-Oct	S1	0	1	1	0	0	0	0	2	0	0	0
15-Nov	S1	0	1	0	0	1	0	0	2	0	0	0
17-Nov	S1	0	0	1	0	0	0	0	1	1	0	0
22-Nov	S4	0	1	0	0	1	0	0	2	0	0	0
24-Nov	S3	0	1	1	0	0	0	0	2	0	0	0
	S4	0	1	0	0	1	0	0	2	0	0	0
27-Nov	S1	0	1	0	0	1	0	1	2	0	0	0
	S3	0	1	1	0	0	0	0	2	0	0	0
29-Nov	S1	0	1	0	0	0	0	0	1	0	0	0
	S3	0	3	1	0	1	0	0	5	0	0	0
	S4	0	3	1	0	2	0	0	6	0	0	0
01-Dec	S1	6	4	8	2	0	1	0	13	2	0	0
	S2	3	2	0	0	0	0	0	2	0	0	0
	S3	8	23	16	1	6	4	1	49	10	0	0
04-Dec	S4	22	2	2	0	0	0	0	4	0	0	0
07-Dec	S4	15	38	44	2	8	6	1	96	0	0	0
	S5	15	16	23	2	2	4	0	45	0	0	0
11-Dec	S1	0	1	0	0	0	0	0	1	1	0	0
	S2	0	0	0	0	0	0	0	0	0	0	0
	S3	0	0	1	0	0	0	0	1	0	0	0
	S4	0	1	2	0	0	0	0	3	0	0	0
13-Dec	S4	4	4	6	0	0	0	0	10	0	0	0
	S4	0	25	32	0	8	4	0	69	1	0	0
	S5	3	5	12	0	1	3	0	21	0	0	0
15-Dec	S1	6	4	11	0	0	0	0	15	1	0	0
	S2	0	0	0	0	0	0	0	0	0	0	0
	S3	3	32	20	0	2	2	0	57 a	6	0	0
18-Dec	S4	3	1	4	0	0	0	0	5	0	0	0
	S4	13	15	26	0	4	4	0	49	1	0	0
	S5	10	12	12	0	2	3	0	29	0	0	0
20-Dec	S1	0	14	8	0	0	0	0	22	2	0	0
	S2	0	1	0	0	0	0	0	1	0	0	0
	S3	6	5	2	0	0	0	0	7	2	0	0
27-Dec	S4	2	24	27	0	6	6	0	63	1	0	0
	S4	1	5	2	0	0	0	0	7	0	0	0
	S5	6	4	7	0	0	2	0	13	0	0	0
29-Dec	S1	0	1	14	0	0	0	0	15	2	0	0
	S2	0	0	2	0	0	0	0	2	0	0	0
	S3	3	7	15	0	0	1	0	25 b	4	0	1
12-Jan	S1	0	4	4	2	0	0	0	8	3	0	1
	S2	0	0	0	0	0	0	0	0	0	0	0
	S3	0	4	11	0	0	0	0	15	0	0	0
	S4	0	0	1	0	0	0	0	1	0	0	0
	S4	0	7	15	0	0	0	0	22	0	0	0
	S5	0	3	5	0	0	0	0	8	0	0	0

Appendix 7a. Summary of live observations and dead counts of coho salmon in the Salmon River, 1989-90.

			Dead count									
			Adipose fin present			Adipose fin absent						
Date	Reach	Live count	Male	Female	Jack	Male	Female	Jack	Adult total	Disk tag and secondary mark	Second-ary mark only	Disk tag only
Total	S1	-	32	47	4	2	1	1	82	12	0	1
	S2	-	3	2	0	0	0	0	5	0	0	0
	S3	-	76	68	1	9	7	1	163	22	0	1
	S4	-	127	162	2	30	20	1	339	3	0	0
	S5	-	40	59	2	5	12	0	116	0	0	0
	Total	-	278	338	9	46	40	3	705	37	0	2

a. Includes one carcass of unknown sex.
b. Includes two carcasses of unknown sex.

Appendix 7b. Summary of live observations and dead counts of coho salmon in Coghlan Creek, 1989-90.

Date	Reach	Live count	Dead count									
			Adipose fin present			Adipose fin absent			Adult total	Disk tag and secondary mark	Secondary mark only	Disk tag only
			Male	Female	Jack	Male	Female	Jack				
22-Nov	C1	0	1	2	0	1	0	0	4	0	0	0
24-Nov	C1	0	2	0	0	0	0	0	2	0	0	0
	C5	0	3	6	0	1	4	1	14	0	0	0
27-Nov	C1	0	3	0	0	0	0	0	3	0	0	0
29-Nov	C1	0	0	1	0	0	0	0	1	0	0	0
07-Dec	C1	130	37	21	5	2	1	0	61	4	0	0
	C2	32	18	24	1	0	1	0	43	0	0	0
	C3	22	18	14	2	1	1	0	34	0	0	0
	C4	19	24	19	3	2	6	0	51	10	0	1
	C5	24	7	5	0	2	4	2	18	2	0	0
11-Dec	C1	0	4	10	0	0	2	0	16	5	0	0
13-Dec	C3	9	15	8	2	1	2	0	26	2	0	0
	C4	15	9	6	0	2	2	0	19	0	0	0
	C5	4	4	5	0	2	0	0	11	0	0	0
15-Dec	C1	11	11	19	4	0	1	0	31	0	0	0
	C2	17	11	17	2	2	4	0	34	1	0	0
18-Dec	C1	7	0	2	0	0	0	0	2	0	0	0
	C2	15	3	3	1	0	1	0	7	0	0	0
	C3	11	7	9	0	1	1	0	18	1	0	0
	C4	7	7	7	3	1	1	1	16	0	0	0
	C5	10	2	2	0	0	1	0	5	1	0	0
20-Dec	C1	8	8	9	1	0	0	0	17	4	0	0
27-Dec	C3	5	2	7	0	1	0	0	10	0	0	0
	C4	0	11	17	1	0	4	0	32	2	0	0
	C5	3	1	7	0	0	1	0	9	0	0	0
29-Dec	C1	0	14	19	0	1	1	0	35	5	0	0
	C2	10	15	15	0	1	0	0	31	0	0	0
03-Jan	C3	0	2	4	0	0	0	0	6	0	0	0
	C4	0	3	4	1	0	0	0	7	0	0	0
	C5	0	0	0	0	0	0	0	0	0	0	0
08-Jan	C1	1	19	19	4	0	0	0	39 a	2	0	1
	C2	0	2	6	0	0	0	0	8	0	0	0
	C3	0	2	5	0	0	0	0	7	0	0	0
	C4	0	2	1	0	0	0	0	3	0	0	0
	C5	0	1	1	1	0	0	0	2	0	0	0
Total	C1	-	99	102	14	4	5	0	211	20	0	1
	C2	-	49	65	4	3	6	0	123	1	0	0
	C3	-	46	47	4	4	4	0	101	3	0	0
	C4	-	56	54	8	5	13	1	128	12	0	1
	C5	-	18	26	1	5	10	3	59	3	0	0
	Total	-	268	294	31	21	38	4	622	39	0	2

a. includes one carcass of unknown sex

Appendix 8. Spawning success of female adult coho spawning ground recoveries, 1989-90.

		Percent spawned			
		0%	50%	100%	Weighted mean
Disk tag or secondary mark	Number	5	2	25	32
	Percent	15.6%	6.3%	78.1%	81.3%
Unmarked	Number	3	2	89	94
	Percent	3.2%	2.1%	94.7%	95.7%
Total	Number	8	4	114	126
	Percent	6.3%	3.2%	90.5%	92.1%

Appendix 9. Observed and estimated coho adult escapement, by CWT code, in the Salmon River system, 1989-90.

		CWT Code			No CWT		
	Total	02 49 38	02 57 25 a	02 57 25 a	Jack	Adult	CWT lost
Estimated AFC escapement	921 b	-	-	-	-		-
No. AFCs recovered	152	-	-	-	-		-
Observed CWT codes	142 c	136	2	4	1	9	-
Estimated escapement by code	-	864	-	-	-	57	-

a. Recovered from 1987 brood coho jacks.

b. Adults only.

c. Excludes 10 with no CWT.

Appendix 10. Incidence of CWT loss by carcass condition and eye status in AFC coho adults carcasses in the Salmon River system, 1989-90.

Group	Sample size a	CWT absent	CWT loss (%)
Condition 1	28	4	14.3%
Condition 2	91	2	2.2%
Condition 3	21	3	14.3%
Condition 4	3	0	0.0%
Eyes present	110	6	5.5%
Eyes absent	33	3	9.1%
Complete AFC	131	9	6.9%
Partial AFC	12	0	0.0%

Appendix 11. Mean length, by sex and age, of Salmon River system coho spawners, 1989-90.

Sample	Age	Sex	Sample size	Percent	Length (cm) Mean	Standard deviation	Range
Application sample a, b	-	Male	249	50.5%	52.2	7.0	29.3 - 68.9
	-	Female	244	49.5%	55.6	4.6	41.0 - 69.0
Recovery sample c	3/2	Male	114	46.2%	43.5	5.1	29.2 - 56.3
		Female	126	51.0%	46.2	4.1	35.2 - 56.8
	2/2	Male	7	2.8%	26.0	2.0	24.0 - 29.5
	Total	Male	121	49.0%	42.5	6.4	24.0 - 56.3
		Female	126	51.0%	46.2	4.1	35.2 - 56.8

a. Not adjusted for sex identification errors.
b. NF length.
c. POH length.